Application of fuzzy inference to the diagnosis of prostatic cancer by transrectal ultrasonography

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Transrectal ultrasonography has assumed an important position in the management of a urological disease. We adopted digital examination and transrectal sonography for initial mass screening for prostatic cancer. However, ultrasonographic assessment of prostatic cancer is heterogenous, and the clinical assessment by ultrasonography may depend on the physician. It can therefore be said that diagnosis is equivocal and judgement is subjective. The purpose of this study was to devise a diagnostic system for prostatic cancer by ultrasonography using a personal computer based on a fuzzy inference¹', which allows objective assessment and consistent diagnosis to be performed even by less experienced urologist.

In order to develop a diagnostic logic, we evaluated the sonograms of 30 patients with untreated prostatic cancer and 34 patients with benign prostatic hyperplasia, histologically proven. A chair-mounted transrectal probe with a 5 MHz (ALOKA 520 scanner) was used to perform sonography, and transverse images of the prostate were recorded at 5-mm intervals (Fig. 1.).

The Japanese Urological Association and the Japanese Society of Ultrasonics in Medicine have published "General Rules for Ultrasonic Diagnosis of Prostatic Cancer"²'. We used 5 of their 7 criteria: shape of the plane, architecture of the shape, capsule echogenicity, similarity of the planes, and internal echogenicity, and added two items, identification of hypoechoic lesion and shift of the posterior basal margin³. A fuzzy scale was used to estimate the degree of each
item and fuzzy inference was adopted for the diagnostic logic. Membership functions were prepared for each item, and the final assessment was made by the center of gravity of the max-sets of the membership function for output. The data of each finding can be input onto a fuzzy scale, using a mouse key (Fig. 2).

In our clinical trial using this computer system, there was only one false negative case and two cases in the fuzzy zone out of 30 untreated cases with prostatic cancer and one false positive case and three cases in the fuzzy zone out of the 34 benign prostatic hyperplasia cases. Therefore, sensitivity was 96.9% and specificity was 89.0% in our series.

Our diagnostic system for prostatic cancer using ultrasonic imaging has the following characteristics: 1. Input of data by fuzzy scale, 2. Outcomes described by membership functions based on a fuzzy inference, 3. Interaction effect of particular items, and 4. Individualization of the diagnostic process.

In conclusion, our newly devised computer diagnostic system is a better method for initial screening for prostatic cancer because of its high sensitivity and specificity.

References:
Fig. 1. Transrectal ultrasonogram of prostatic cancer.

Fig. 2. Computer display of outcomes based on input data of findings onto fuzzy scale.